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Applied Research on Traffic Information Collection Based on Wireless Sensor Networks

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Abstract

Traditional traffic information collection network bears some disadvantages, such as high-concentrated system load, low-usage of network, limited network pavement, and shocking operation cost and so on. Therefore, this paper proposes to design a brand new traffic information collection system based on wireless sensor networks, in which the distributed treatment of traffic information collection is realized. This paper also puts forward the structure framework of traffic information collection system based on wireless sensor network, and discusses the potential problems in the implementation and related resolution strategies.

Keywords: Wireless sensor networks. Traffic information collection and processing.

1. Introduction

Traffic information collection is one of the crucial and basic parts of Intelligent Traffic System(ITS), and it is also the basic for road design, traffic management and control, traffic design and implementation of ITS and theoretical research of traffic flow. The survey and analysis of traffic can help to know the traffic condition and nature of traffic problems, and to propose the resolutions; on the basis of overall and systemic survey on traffic network, the traffic change regulations can be analysed, and so as to provide the literature for traffic flow theory model and traffic prediction model, and offer the basis for the implementation of information service for the subsystem of ITS.

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The current commonly-used traffic information collection is based on inductive loop detector,microwave detection, video detection and infrared detection. The traffic information collection of using inductive loop detector is today's quite mature vehicle detection method. It can acquire the traffic flow of monitoring road, usage, speed and so on, and so as to judge traffic jam condition, and finally show the handled information through display device. Nowadays, this method has been standardized and it can be easily mastered.Besides, systems based on this method run stably and they are less interferenced by the external environment.

Microwave vehicle detector, i.e. ITMS (Intelligent Traffic Microwave Sensor). It is to use microwave and high-speed digital signal handling way, and also to detect multi-lane or the area's vehicle flow, occupancy, car-speed, car length and etc. ITMS is a traffic information collection method of high cost-performance ratio and it can be widely used in urban traffic intersections's or highways' information collection.

Video vehicle detector is operated using vidicon as a sensor, and setting virtual line in the video scope, that is the detecting area. When a car runs into the detecting area, the background grey value begins to change. Therefore, the existence of cars can be detected as well as the car flow and speed.

Infrared ray vehicle detector is operated through infrared ray to scan the vehicle, converting the optical signal to digital signal, to realize the overall detection of the data.

Though the above four methods can complete traffic information collection, there exist disadvantages, for example, we must dig ditches in the traffic lane if we want to use a infrared loop detector, however, in practice, the preservation work is heavy due to the weak roadbed of the expressway and higher damaging rate in the preservation work. The data are accurate, but not direct. Microwave detection device needs to be put 3 meters to the nearest lane, so it is limited when set on the bridge, overpass and viaduct. Oversized vehicle can shelter the automobiles, and shade and change of day and night can lead to errors. Due to the fact that infrared ray is weak in penetrating the dust, clouds, rain and snow, this device can not work in such environments.

The above traditional traffic information collection have disadvantages, so this paper proposes a new traffic information collection system based on wireless sensor network, which is benefit from recent rapid development of wireless sensor network and distributed collection. This system uses embedded mobile devices of detecting, handling, wireless communicating functions as the basic nodes in wireless networks, and each node constitutes a network through ad-hoc, and handles traffic information and environmental information so as to realize collection, processing and transmission. In this network, information processing and transmission are not limited to traffic management center. The raw data are dealt at the node, information transmitted in the network, and useful information collected and transmitted to other terminals and traffic management center for data support. The construction of wireless sensor network can reduce the wires and the rent cost, avoiding the damage to the road, and improving the flexibility and effectiveness of information collection.

The next part will discuss the construction of traffic information collection system based on wireless sensor network and its problems. The second part will discuss the overall structure framework, and the third will discuss the crucial problems when implemented and related resolutions. The last part discusses its current research condition and next priorities.

2. The Overall Framework of Traffic Information Collection System Based on Wireless Sensor Network

Wireless sensor network, constituted through ad-hoc aims to percept coordination, collect and handle the perception information in the areas, meanwhile to show to the observers. Here, the observer is the user of sensor network, and the receiver and applier of the perception information. The perception object is the target of the observer's, and the perception object of sensor network, such as tank, vehicle, animal,

and damaging air and so on. Perception object usually displays through physical, chemical and other statistics, such temperature, humidity and so on. One sensor network can percept many objects in the network, while one object can be percepted by various sensor network.

The typical structure of sensor network is shown in Fig.1. This network structure composes of sensor node, sink, Internet or satellite, task management node and so on. Sensor nodes are distributed in designed perception areas with each collecting statistics and transmitting to Sink through "multi-hop" route. Sink can transmit statistics to each node using the same way. Sink is directly linked with Internet or satellite to realize the communication between task management node (observer) and the sensor.

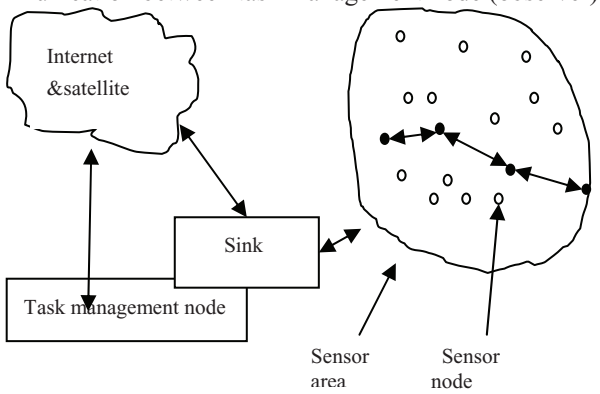

Fig.1 A typical sensor network

In different usage, the design of sensor node is different, but of the same basic structure. See Fig.2. Sensor node is usually made up by power supply, perception component, embedded processor, memory, communication component, softwares and so on. Power supply provides daily necessary power for the sensor. Perception component is used for perception, acquisition of outer information and convert it to digital signal. Processor is responsible for the coordination of the work, such as dealing with and storing the information acquired by perception component, monitoring the working model of perception component and power supply. Communication component communicates with other sensors and observers. Software provides necessary software support for sensor, such as embedded operating systems and embedded database systems.

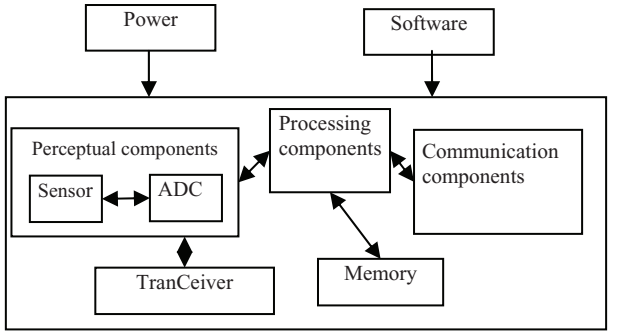

Fig. 2 Schematic diagram of sensor

In this system, terminal sensor node adopts untouchable geomagnetism senor to collect and percept the car speed, car space, and so on. When the car enters the monitoring scope, sensor node collects some important information of the cars through magnetism sensor, pass the information to next node. When the next node percepts this car, the average speed can be calculated using the driving time between the first node. Some terminal nodes gather the information they early collect and deal with to gateway node and acquire the car flow and speed, in order to offer input information to the crossing traffic signals. Various sensors concerning humidity, illuminance, gas are set up in nodes so as to monitor the road condition, visibility, tail gas pollution.

3. The crucial problems and resolutions of the system design

Compared with traditional network, wireless sensor network has the advantages of a good quantity of nodes, huge distribution density, limited node power energy. The wireless sensor network not only has the node which has the monitoring functions, but also its function is closely related to the geography and connection of node. How to set up this new network, to initialize the network, to organize the connection of the nodes are the key factors in how the performance of the network will be. What's more, the wireless sensor network determines its application in transportation different from traditional digital traffic system. Specifically speaking, the implementation of this system need to solve the following three problems:

1) The energy of sensor's power supply is limited

The energy of sensor's power supply is quite limited. Due to the the energy of power supply the sensor is usually less effective and abandoned. Energy of power supply limitation severely blocks the application of sensor network. The commercialized wireless sink power can not satisfy the needs of sensor network. The transmission of wireless receiver costs much power than the sensor network. The energy needed for transporting 1-bit information by sensor is adequate for executing 3000 instructions. How to save energy in network and optimize the life circle of the network is the first challenge.

2) The sensor is quantitative and has a wide coverage

The sensor nodes in the sensor network are intensive and quantitative, probably amounting to millions and more. In addition, they can cover a wide area. The quantity of the sensor and user usually demands a great deal. This feature leads to the difficulty in developing and managing the network, and even impossible to manage. This is the second challenge.

3) The nodes can not realize synchronization

In the sensor network, each node has its own clock. Since there exist frequency errors among different nodes' crystal oscillators and environment interference,even though all the nodes are in synchronization at a certain time, their clock can cause error gradually. The coordination of wireless sensor network needs the synchronization of each node. Therefore, the mechanism of clock synchronization is the key problem. What's more, because of the small size of sensor node, limited energy, and high price, synchronization in the traditional system is not suitable for wireless sensor network. This is the third challenge.

Based on above problems, we propose following resolutions:

1) To acquire the energy from outside environmental continuous vibration

It is absolutely possible to acquire the energy from outside environmental continuous vibration to make wireless sensor work. Potential application areas cover: monitoring device condition, monitoring High Level AC Voltage, monitoring vehicle tyre pressure and monitoring planes' and ships' potential problems before their voyage. These devices are quite effective and flexible, those vibration that can not be felt by human beings can be percepted and cause current. The input of vibration uses g as a unit which equals to acceleration of gravity. (humans can feel the vibration caused by the touch by 0.02g) . Energy capture devices can change the vibration of 28Hz, 100mg into power and can output the power by 9.3mW. The increase of the volume leads to the increase of the its power. The relationship between the output power and thevibration frequency is linear, while it has a exponential relationship between the

output power and the vibration intensity. When the newly-born power can not be used immediately, they will be stored in a super electric capacitor. The molding products based on this way to produce power have come out in the world.

2) Solutions based on hierarchical topology control

The principal of hierarchical topology control is that it selects certain nodes to be the backbone nodes, opens their communication modules, closes the communication modules of the non-backbone nodes and buids a communication network fulfilling the coverage rate. so, it will not only ensure the data communications within the original coverage area but also, to a great extent, save the nodes' energy. With respect to hierarchical topology control, some algorithms have already been proposed, such as TopDisc, HEED, LEACH, GAF and etc.

3) Solutions based on synchronization of the root node clock

This aims to realize the overall network clock sychronization. This resolution needs a outside node, on which there can set up certain complicated hardware such as GPS as the clock source of the overall network. Firstly, this resolution levels all the nodes and then makes the clock synchronization according to each level, with each node synchrozed with upper node and synchronized with root node finally.

4. Conclusion and Outlook

This paper has proposed a completely new and WSN-based distributed traffic information collection system. In this paper, we have discussed the architecture framework of the wireless sensor network, the potential problems during the system implementation and the corresponding solutions. At present, this project has made some achievements in solving nodes energy, network topology planning and clock synchronization among nodes. Next,we will do some detailed research on node-locating technology and the key technology of sensor network data management.

We believe, on the basis of the achievements in research and after the WSN-based traffic information collection system being put into use, that setting up a intelligent traffic system will becom much easier and more applications will be developed. Meanwhile, of course, there will be some new issues that we need to resolve.

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